Design Optimization of Additively Manufactured Sandwich Beams Through Experimentation, Machine Learning, and Imperialist Competitive Algorithm

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What is the outcome or accomplishment? (1-2 short sentences describing it and why it is transformative; 50-word maximum suggested)*

The study successfully achieved optimized designs for 3D-printed sandwich beams with auxetic cores through a combination of experimentation, deep neural networks, and the Imperialist Competitive Algorithm. By employing Taguchi's experimental design, testing, and machine learning, the research generated insights into lightweight structure optimization. The integration of these methodologies showcased the potential for efficient and precise design improvement, laying a foundation for future advancements in 3D-printed lightweight structures.

What is the impact? (1-2 simple sentences describing the benefits for science, industry, society, the economy, national security, *etc.*; suggested 50-word maximum)

The impact of this study lies in the successful integration of experimentation, machine learning, and the Imperialist Competitive Algorithm to optimize 3D-printed sandwich beams with auxetic cores. By introducing an innovative approach that combines advanced manufacturing techniques, predictive modeling through deep neural networks, and a metaheuristic algorithm, the study offers a systematic framework for designing lightweight structures with minimal mass. The optimized designs, as illustrated by the contour plot, provide valuable insights into the distribution of mass under various conditions and constraints. The study contributes not only to the specific domain of lightweight sandwich structures but also underscores the broader applicability of the methodology in enhancing efficiency and innovation in materials engineering.

What explanation/background does the lay reader need to understand the significance of this outcome? (1-2 paragraphs that might include, for example, more on who, when, where; NSF's role; support from multiple directorates/offices; what makes this accomplishment unique; additional intellectual merits; or broader impacts such as education, outreach, or infrastructure improvement that are integral to this outcome; suggested 150-word maximum)

To understand the significance of the outcome in this study, the lay reader needs some background on 3D-printed sandwich beams with auxetic cores. These structures are designed with specific

geometric variations, including core thickness, width, and parameters related to the auxetic core's geometry. The optimized 3D-printed sandwich beams with auxetic cores find practical applications in aerospace, automotive, and construction, offering lightweight, customizable structures.

The combination of a Deep Neural Network (DNN) and the Imperialist Competitive Algorithm (ICA) in this study provides a powerful synergy. The DNN accurately predicts bending response and mass, serving as a surrogate model for the complex structural behavior. Integrating the DNN within the ICA optimization framework harnesses the algorithm's global search capability, effectively navigating the design space to find optimal solutions efficiently.

This breakthrough methodology not only enhances the efficiency of 3D-printed sandwich beams but also serves as a reference for future research, showcasing the potential of combining advanced manufacturing, machine learning, and optimization algorithms in materials engineering for lightweight structures.